Mesoscale Dynamics of the Adriatic Sea

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LONG-TERM GOALS

A better understanding of oceanic variability via modeling studies of circulation, entrainment, mixing and convection in the coastal ocean. Development and use of high-resolution models for the study of generic processes and for the investigation of specific oceanic regions. Transition of these models to the US Navy.

OBJECTIVES

The particular objective of this project is to understand the physics of the mesoscale motions across the Adriatic Sea well enough to simulate them faithfully in high-resolution models.

APPROACH

The approach is two-fold, combining (1) the development of a very-high-resolution 3D model for the entire Adriatic basin with (2) the analysis of existing satellite images revealing mesoscale spatial patterns. The selected model is DieCAST because of its extremely low level of dissipation at the grid scale, and the satellite images of choice are AVHRR and SeaWiFS, especially the latter because of the high level of details they provide.

WORK COMPLETED

By far, the main piece of work completed to date is the successful application of the 4th-order accurate DieCAST numerical model of the entire Adriatic basin with a 2-km horizontal resolution and 21 levels in the vertical, with open-boundary conditions at Otranto Strait provided by a larger model of the eastern Mediterranean.

For comparison purposes, the Princeton Ocean Model (POM) has also been implemented for the Adriatic Sea with the same horizontal and vertical resolution. Comparisons between outputs from both models (DieCAST and POM) have begun.

A critical analysis of a multi-year set of SeaWiFS images (showing mesoscale patterns through surface chlorophyll) has been conducted in order to identify and categorize the various types of mesoscale features across the Adriatic.

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As opportunities arise and spontaneous ideas emerge, some work connected with semi-enclosed bodies of water is pursued alongside the main objectives of this project. This year saw the publication of a paper on Mururoa and led to an original study of the effect of density stratification on surface waves, explaining among other things the variability noted in the frequency of long waves in the Adriatic.

Remark: The post-doc, who is essential for the running the model, has had his visa seriously delayed, and the three months of 2003 to be devoted by him to this project have yet to get underway.

RESULTS

The DieCAST model has sufficiently low numerical dissipation to allow mesoscale instabilities to develop at short horizontal length scales, and the simulated variability occurs on the correct length and time scales. Furthermore, features appear to be produced at the proper locations and in realistic groupings (such as a squirt off Rimini, a recurrent triplet of meanders South of Ancona, a front perpendicular to the Croatian coast at the level of Jabuka Pit, and a swirl in the wake of the Gargano Peninsula – see Figure 1). Judging from the several presentations on modeling of the Adriatic Sea at the AGU-EGS-EUG joint assembly in Nice last April 2003, this model is the only one to date capable of capturing the mesoscale instabilities of the Adriatic Sea. In contrast, POM results reveal excessive damping, and the associated velocity distributions do not contain the expected meanders and eddies.

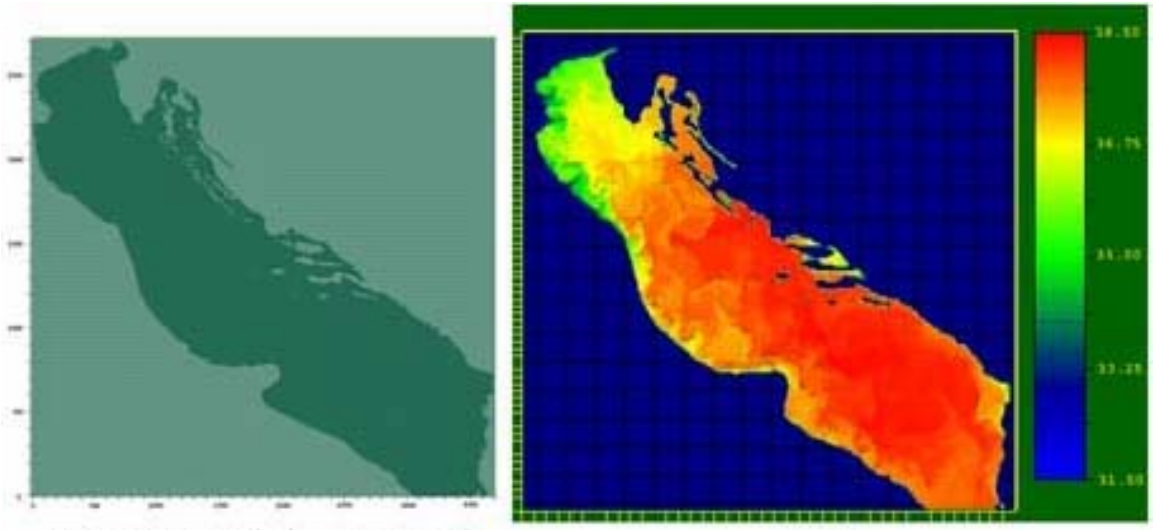

Figure 1. Model grid (left) and sample simulation of surface salinity (right) showing level of details achieved by the DieCAST model of the Adriatic Sea.

A dynamical analysis of the simulated meanders and squirts along the Italian coastline reveal a nearly textbook-perfect case of baroclinic instability. The nature of mesoscale motions on the Croatian side of the sea remains to be elucidated.

The numerical simulations with DieCast and the independent analysis of SeaWiFS images both reveal that variability in the Po River discharge triggers new meanders and filaments along the Italian coast, whereas larger and more persistent eddies in the northern Adriatic are generated following episodes of bora winds. Although it appears that variability in the currents and fronts along the Croatian coast are connected to perturbations occurring to the South, a verdict on this matter has not yet been reached.

IMPACT/APPLICATIONS

The results to date demonstrate that effective simulations of the mesoscale variability of the Adriatic Sea require a low-dissipation model and a grid resolution of at least 2 km. This ought to impact the Mediterranean Sea models currently used by the US Navy.

RELATED PROJECTS

This project is a component of the multi-project initiative concurrently funded by ONR-PO and focusing on the Adriatic Sea. Related projects are those of Craig Lee (Univ. Washington, TriSoarus towed profiling), Pierre Flament (Univ. Hawaii, HF radar and remote sensing), Pierre-Marie Poulain (OGS-Trieste, surface drifters), and Mirko Orlic (Univ. Zagreb, East Adriatic Coastal Experiment).

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